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Rocky Mountain Research Station

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If a Tree Falls in the Forest … Snagfall Dynamics in Western Forests More Than a Decade After a Severe Beetle Outbreak

A mountain pine beetle outbreak beginning in the early 2000s created oceans of standing dead trees in extensive areas of forest in western North America, changing the landscape for generations. In some areas, more than 75 percent of the forest overstory was killed by the beetles, which now persists in the form of snags or downed trees. Whether the snags stay standing—or fall and add dead wood to the forest floor—has implications for ecosystem processes, managing fuels, salvage logging, and conserving wildlife habitat.

Recently published work by Rocky Mountain Research Station's (RMRS) research biogeochemist Chuck Rhoades and colleagues took a detailed look at the trajectory of beetle-killed wood 10 and 12 years after the mortality rate peaked in 2006 in high-elevation forests of north-central Colorado. Their work has helped address the question of whether snagfall rates at higher elevations are similar to lower elevation rates. This can help to develop and refine projections of post-outbreak surface and standing fuels, harvest possibilities, cavity and coarse wood wildlife habitat, stand regeneration, and carbon storage.

Over half of the overstory snagfall at the Fraser Experimental Forest was caused by butt rot, where the snag rots at the base and snaps off at ground level. These trees tended to fall in a downhill direction (USDA Forest Service photo by Chuck Rhoades).

Where a Tree Falls in the Forest

A whopping 78 percent of the overstory lodgepole pine were killed by the pine beetles in the study plots at the USDA Forest Service Fraser Experimental Forest in north-central Colorado, where Rhoades studied the snagfall. Of those, only 17 percent fell since 2018, 12 years after the peak of the outbreak, meaning that there were still lots of standing dead trees in these forests. The researchers looked at how downed trees (beetle-killed lodgepole pine but also subalpine fir and Engelmann spruce) ended up on the ground— meaning, did they rot and fall over or were they blown over or snapped by wind? It turns out that these mechanisms tended to result in different orientations on the ground. If the snags rotted and fell at ground level (butt rot), they tended to be oriented downhill. Butt rot accounted for slightly over half of the overstory snagfall. On the other hand, if they were tipped up or snapped by winds, they were oriented in the direction of the prevailing wind.

The Long-Term Legacy of High-Elevation Snagfall

Although most dead trees were still standing after 12 years, the pace of snagfall into the future is expected

to be more rapid. Rhoades estimates that one-half of the beetle-killed trees at these high-elevation sites will fall within about 15-20 years after the peak of the outbreak, compared to a half-life of 7.5 to 10 years documented for snags at lower elevations. This means that the influence of the beetle outbreak on snag dynamics in these higher elevation forests—where dead trees rot more slowly due to colder temperatures—could last more than two decades, with some decay-resistant lodgepole pine snags likely to last for decades longer. Salvage logging could be complicated in these areas due to butt rot in the snags and large numbers of pine seedlings on the ground. However, some snags could retain some timber and biomass value.

Rhoades notes, "There was quite a bit of snagfall during the big wind events of 2020, and we may end up rewriting some of these projections." He also noted that in the recent Colorado wildfires, standing dead trees comprised much of what burned—influencing fire severity and fire effects.

"Not all the fire effects were right on the ground because the dead trees burned while standing," he explains. "Both the wind events and fires of 2020 have taken out a big chunk of these standing dead trees."

About one-third of the snagfall was caused by tip-ups, which tended to fall in the direction of the prevailing wind (bole breakage was a third, but uncommon, type of snagfall) (USDA Forest Service photo).

KEY MANAGEMENT CONSIDERATIONS

- A bark beetle outbreak killed 78 percent of overstory lodgepole pine on high-elevation study plots at the Fraser Experimental Forest in north-central Colorado. Of those snags, only 17 percent fell in the first decade after the peak of the outbreak.
- The causes of snagfall determined how they were oriented on the ground. Butt rot snagfall tended to fall downhill, and tip-ups were more likely to fall in the direction of the prevailing wind.
- Post bark beetle outbreak snagfall dynamics create a multiple-decade legacy that will persist longer in high-elevation compared to lower-elevation forests.
- It is estimated that one-half of the beetle killed lodgepole pine in high-elevation forests such as those at Fraser may fall within 15 to 20 years of beetle infestation, but that some pine snags are likely to persist for decades longer.

PROJECT LEAD

Chuck Rhoades is a research biogeochemist at the Rocky Mountain Research Station in Fort Collins, CO. He studies linkages between terrestrial and aquatic ecosystems in managed and unmanaged areas. Connect with Chuck at https://www.fs.usda.gov/rmrs/people/crhoades.

FURTHER READING

Rhoades, C.C.; Hubbard, R.M.; Hood, P.R.; Starr, B.J.; Tinker, D.B.; Elder, K. 2020. Snagfall the first decade after severe bark beetle infestation of high elevation forests in Colorado, USA. Ecological Applications. 30(3): e02059.

Rhoades, C.C.; Hubbard, R.M.; Elder, K.; Fornwalt, P.J.; Schnackenberg, E.; Hood, P.R.; Tinker, D.B. 2020. Tree regeneration and soil responses to management alternatives in beetle-infested lodgepole pine forests. Forest Ecology and Management. 468: 118182.

Rhoades, C.C.; Hubbard, R.M.; Elder, K. 2017. A decade of streamwater nitrogen and forest dynamics after a mountain pine beetle outbreak at the Fraser Experimental Forest, Colorado. Ecosystems. 20: 380–392.

The Rocky Mountain Research Station is one of seven units within USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state geography encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests, ranges and watersheds and maintains long-term research databases for these areas. Our science improves lives and landscapes. More information about Forest Service research in the Rocky Mountain Region can be found here: https://www.fs.usda.gov/rmrs/.